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Educational Product	
Educators	Grades 3-5

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The NASA SCI Files™
The Case of the
Shaky Quake

**A Lesson Guide with Activities in
Mathematics, Science, and Technology**

Please Note: Our name has changed! The NASA "Why" Files is now the NASA SCIence Files™ and is also known as the NASA SCI Files™.

The Case of the Shaky Quake lesson guide is available in electronic format through NASA Spacelink - one of NASA's electronic resources specifically developed for the educational community. This publication and other educational products may be accessed at the following address: **http://spacelink.nasa.gov/products**

A PDF version of the lesson guide for NASA SCI Files™ can be found at the NASA SCI Files™ web site: **http://scifiles.larc.nasa.gov**

The NASA Science Files™ is produced by the NASA Center for Distance Learning, a component of the Office of Education at NASA's Langley Research Center, Hampton, VA. The NASA Center for Distance Learning is operated under cooperative agreement NCC-1-02039 with Christopher Newport University, Newport News, VA. Use of trade names does not imply endorsement by NASA.

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The Case of the Shaky Quake

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Segment 1

Segment 2

Segment 3

Segment 4

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Registered users of the NASA SCI Files™ may request a Society of Women Engineers (SWE) classroom mentor. For more information or to request a mentor, e-mail **kim.tholen@swe.org**

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Program Overview

One afternoon, the tree house detectives feel their tree house shake. They wonder what could have caused the vibration. Unsure whether they had just experienced an earthquake, the tree house detectives decide to make the unexplained vibration the subject of their next case and set out to solve *The Case of the Shaky Quake.*

To solve this mystery, the detectives decide that a seismologist will know the answer, but they quickly learn that it is not that simple. They realize that research is a must, and they call Dr. D to help them get started. Dr. D provides an explanation of the layers of the Earth and how fossils helped scientists discover the movement of the Earth's crust. He also tells them that the answer to a problem is not always obvious. The detectives begin to think of possibilities other than earthquakes that could have caused the ground to shake.

To further investigate the movement of the Earth's crust, Jacob visits Dinosaur National Monument in Utah and decides that his visit will be a great opportunity to learn more about the crust's movement. There he meets Mr. David Whitman, who tells Jacob about the Continental Drift Theory and how fossils and rocks are clues that help unlock the mystery of our Earth's past. The tree house detectives also contact the United States Geological Survey (USGS) office for information on faults and boundaries.

The tree house detectives continue their investigation at Tidewater Community College in Virginia Beach, Virginia, where Mr. Michael Lyle shows them how earthquakes are recorded, and Dr. D explains how they can make their own seismometer. They carry on with their quest at the NASA Jet Propulsion Laboratory (JPL), where Andrea Donnellan demonstrates how NASA monitors crustal movement from space.

The tree house detectives think they are getting close to solving the mystery, and R.J. and Jacob agree to meet Dr. D at the California Academy of Sciences in San Francisco, California to learn more about earthquake waves and how they travel. Dr. Carol Tang joins them and explains how earthquakes are measured and how they destroy buildings. Dr. D, Dr. Tang, R.J., and Jacob all hang on for a wild ride as they "experience" an earthquake in the earthquake room at the Academy.

Back in the tree house, the detectives dial up a NASA SCI Files™ Kids Club in Norfolk, Virginia to learn how the epicenter of an earthquake is located. Finally, the detectives head back to JPL to speak with Ron Baalke to learn about something totally unexpected and discover the answer to why they are "all shook up!"

National Science Standards (Grades K – 4)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Unifying Concepts and Processes				
Systems, orders, and organization	x	x	x	x
Evidence, models, and explanations	x	x	x	x
Change, constancy, and measurement	x	x	x	x
Form and Function	x	x	x	x
Science and Inquiry (Content Standard A)				
Abilities necessary to do scientific inquiry	x	x	x	x
Understanding about scientific inquiry	x	x	x	x
Physical Science (Content Standard B)				
Properties of objects and materials	x	x	x	x
Position and motion of objects	x	x	x	x
Life Science (Content Standard C)				
Organisms and their environments	x	x	x	x
Earth and Space Science (Content Standard D)				
Properties of Earth Materials	x	x	x	x
Changes in Earth and Sky	x	x	x	x
Science and Technology (Content Standard E)				
Abilities of technological design	x	x	x	x
Understanding about science and technology	x	x	x	x
Ability to distinguish between natural objects and objects made by humans	x	x	x	x
Science in Personal and Social Perspective (Content Standard F)				
Personal health			x	x
Changes in environment			x	x
Science and technology in local challenges	x	x	x	x
History and Nature of Science (Content Standard G)				
Science as a human endeavor	x	x	x	x

National Science Standards (Grades 5 – 8)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Unifying Concepts and Processes				
Systems, order, and organization	X	X	X	X
Evidence, models, and explanations	X	X	X	X
Change, constancy, and measurement	X	X	X	X
Form and Function	X	X	X	X
Science as Inquiry (Content Standard A)				
Abilities necessary to do scientific inquiry	X	X	X	X
Understanding about scientific inquiry	X	X	X	X
Physical Science (Content Standard B)				
Properties and changes of properties in matter	X			
Motion and forces	X	X	X	X
Transfer of energy			X	X
Earth and Space Science				
Structure of the Earth system	X	X	X	X
Earth's history	X	X	X	X
Science and Technology (Content Standard E)				
Abilities of technological design	X	X	X	X
Understanding about science and technology	X	X	X	X
Science in Personal and Social Perspectives (Content Standard F)				
Personal health			X	X
Risks and benefits			X	X
Science and technology in society	X	X	X	X
History and Nature of Science (Content Standard G)				
Science as a human endeavor	X	X	X	X
Nature of science	X	X	X	X
History of Science	X			

National Mathematics Standards (Grades 3 - 5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Number and Operations				
Understand numbers, ways of representing numbers, relationships among numbers, and number systems.	X		X	
Understand meanings of operations and how they relate to one another.	X			
Compute fluently and make reasonable estimates.	X			
Algebra				
Understand patterns, relations, and functions.			X	X
Represent and analyze mathematical situations and structures using algebraic symbols.				X
Use mathematical models to represent and understand quantitative relationships.				X
Analyze change in various contexts.				X
Geometry				
Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships.	X			
Measurement				
Understand measurable attributes of objects and the units, systems, and processes of measurement.	X		X	X
Apply appropriate techniques, tools, and formulas to determine measurements.				X
Data Analysis and Probability				
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.	X	X	X	X
Develop and evaluate inferences and predictions that are based on data.			X	X
Understand and apply basic concepts of probability.	X	X	X	X
Problem Solving				
Solve problems that arise in mathematics and in other contexts.	X	X	X	X
Apply and adapt a variety of appropriate strategies to solve problems.	X	X	X	X
Communication				
Analyze and evaluate the mathematical thinking and strategies of others.			X	X
Use the language of mathematics to express mathematical ideas precisely.			X	X

National Mathematics Standards (Grades 3 – 5) Continued

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Connections				
Recognize and use connections among mathematical ideas.				X
Recognize and apply mathematics in contexts outside of mathematics.	X		X	X
Representation				
Select, apply, and translate among mathematical representations to solve problems.	X	X	X	X
Use representations to model and interpret physical, social, and mathematical phenomena.			X	X

National Technology Standards (ITEA Standards for Technology Literacy, Grades 3 – 5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Nature of Technology				
Standard 1: Students will develop an understanding of the characteristics and scope of technology.	x	x	x	x
Standard 2: Students will develop an understanding of the core concepts of technology.	x	x	x	x
Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	x	x	x	x
Technology and Society				
Standard 6: Students will develop an understanding of the role of society in the development and use of technology.	x	x	x	x
Standard 7: Students will develop an understanding of the influence of technology on history.	x			
Abilities for a Technological World				
Standard 12: Students will develop abilities to use and maintain technological products and systems.	x	x	x	x
Standard 13: Students will develop abilities to assess the impact of products and systems.	x	x	x	x
The Designed World				
Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.	x	x	x	x

National Technology Standards (ISTE National Educational Technology Standards, Grades 3 - 5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Basic Operations and Concepts				
Use Keyboards and other common input and output devices efficiently and effectively.	x	x	x	x
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	x	x	x	x
Social, Ethical, and Human Issues				
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	x	x	x	x
Technology Productivity Tools				
Use general purpose productivity tools and peripherals to support personal productivity, remediate skill deficits, and facilitate learning throughout the curriculum.	x	x	x	x
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	x	x	x	x
Technology Communication Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	x	x	x	x
Use telecommunication efficiently and effectively to access remote information, communicate with others in support of direct and independent learning, and pursue personal interests.	x	x	x	x
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	x	x	x	x
Technology Research Tools				
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	x	x	x	x
Use technology resources for problem solving, self-directed learning, and extended learning activities.	x	x	x	x
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	x	x	x	x
Technology Problem-Solving and Decision-Making Tools				
Use technology resources for problem solving, self-directed learning, and extended learning activities.	x	x	x	x

The National Geography Standards, Grades 3 – 5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
The World in Spatial Terms				
How to use maps and other graphic representations, tools, and technologies to acquire process and report information from a spatial perspective.	X	X	X	X
Places and Regions				
The physical and human characteristics of plates.	X	X	X	X
That people create regions to interpret Earth's complexity.	X	X	X	X
Physical Systems				
The physical process that shape the patterns of Earth's surface.	X	X	X	X
Environment and Society				
How physical systems affect human systems.	X	X	X	X
The Uses of Geography				
How to apply geography to interpret the past.	X	X	X	X
How to apply geography to interpret the present and plan for the future.	X	X	X	X

The NASA SCI Files™
The Case of the
Shaky Quake

Segment 1

The tree house detectives are concerned about a tremor that they felt while working in the tree house. Unsure if they had just experienced an earthquake, they decide to call a seismologist to find the answer. They soon realize that it isn't that simple. As the detectives begin their research, they stop by to see Dr. D, who provides them with information on the various layers of the Earth and how fossils help scientists discover the Earth's movement. Dr. D also tells them to think "outside of the box" because the answer is not always obvious. Jacob is on vacation in Utah and visits David Whitman at Dinosaur National Monument to gather some important clues and to learn about the Continental Drift Theory and plate tectonics.

Objectives

The students will

- learn that the interior of the Earth is divided into layers.
- understand continental drift.
- learn that fossils provide evidence about the nature of the environment in which they lived.
- learn that the surface of the Earth slowly changes through time.
- learn the theory of plate tectonics.

Vocabulary

continental drift—a hypothesis that continents have moved around the globe thousands of kilometers over millions of years to reach their current location

crust—the outermost layer of the Earth

density—how tightly packed a substance's molecules are

earthquake—the movement of the ground caused by waves from energy released as rocks move along faults

fossils—the remains or traces of a once-living organism; usually preserved in rock

inner core—the solid center of the Earth

mantel—the thickest layer inside the Earth; it lies between the outer core and the crust

outer core—a liquid layer of Earth's core that surrounds the solid inner core

Pangaea—the name Alfred Wegener gave to the landmass that he believed existed before it split apart to form the present continents

plate tectonics—the theory that Earth's crust and upper mantle exist in sections called plates and that these plates slowly move around on the mantle

seismogram—the record of an earth tremor as made by a seismograph

seismograph—an instrument that records earthquake waves

seismologist—a scientist who studies earthquakes and waves

vibration—a trembling motion

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich the existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 1 of *The Case of the Shaky Quake*, read the program overview (p. 5) to the students. List and discuss questions and preconceptions that students may have about earthquakes, the layers of the Earth, and fossils.
2. Record a list of issues and questions that the students want answered in the program. Determine why it is important to define the problem before beginning. From this list, guide students to create a class or team list of three issues and four questions that will help them to better understand the problem. The following tools are available in the educator area under the resources section of the web site to assist in the process.

   Problem Board - Printable form to create student or class K-W-L chart

   Problem Based Learning (PBL) Questions - Questions for students to use while conducting research

   Problem Log - Printable log for students with the stages of the problem-solving process

   The Scientific Method - Chart that describes the scientific method process
3. Focus Questions - Questions at the beginning of each segment that help students focus on a reason for viewing and can be printed ahead of time from the educator's area of the web site so students can copy them into their science journals. Encourage students to take notes during the program to answer the questions. An icon will appear when the answer is near.
4. What's Up? Questions - Questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. These questions can be printed from the web site ahead of time for students to copy into their science journals.

Careers

seismologist
park ranger
geologist
oceanographer
paleontologist

View Segment 1 of the Video

For optimal educational benefit, view *The Case of the Shaky Quake* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Students should work in groups or as a class to discuss and list what they know about earthquakes, the layers of the Earth, fossils, and plate movement. Have the students brainstorm ideas on what could have caused the tremor that the tree house detectives felt. As a class, reach a consensus on what additional information is needed. Have the students conduct independent research or provide students with the information needed.
4. Have the students complete Action Plans, which can be printed from the web site, and then conduct independent or group research by using books and internet sites noted in the Research Rack section of the NASA SCI Files™ web site. Educators can also search for resources by topic, episode, and media type under the Educator's main menu option *Resources.*
5. Choose activities from the educator guide and web site to reinforce concepts discussed in the segment. The variety of activities is designed to enrich and enhance your curriculum. Activities may also be used to help students "solve" the problem along with the tree house detectives.
6. Have the students work individually, in pairs or in small groups, on the Problem-Based Learning (PBL) activity on the NASA SCI Files™ web site.

- To begin the PBL activity, read the scenario to the students.

- Read and discuss the various roles involved in the investigation.
- Print the criteria for the investigation and distribute.
- Have students use the Research Rack located on the web site and the online tools that are available.

7. Having students reflect in their journals what they have learned from this segment and from their own experimentation and research is one way to assess the students. In the beginning, students may have difficulty reflecting. To help students, give them specific questions to reflect upon that are related to the concepts.

8. Have students complete a Reflection Journal, which can found in the Problem-Solving Tool section of the online PBL investigation or in the Instructional Tools section of the Educator's area.

9. The NASA SCI Files™ web site provides educators with general and specific evaluation tools for cooperative learning, scientific investigation, and the problem-solving process.

Resources (additional resources located on web site)

Books

Cottonwood, Joe: *Quake!* Scholastic, 1995, ISBN 0590222333.

Gallant, Roy A: *Dance of the Continents.* Benchmark Books, 2000, ISBN 0761409629.

Silverstein, Alvin: *Plate Tectonics*. Twenty-First Century Books, 1998, ISBN 076133225.

Simon, Seymour: *Earthquakes*. Morrow Junior Books, 1991, ISBN 0688096336.

Web Sites

Exploratorium—Life Along the Fault Line
This site contains real video clips of experts in the field of geology, along with activities, links, and a place to share your story.
http://www.exploratorium.edu/faultline/index.html

Pangaea To the Present: A History of the Earth's Plates
This web site guides the user through the theory of the formation and breakup of Pangaea. The site includes various maps depicting the transformation of Pangaea through time and a model of the Earth's crust.
http://volcano.und.nodak.edu/vwdocs/vwlessons/lessons/Pangaea/Pangaea1.html

PBS Online—Earth Science Links: Earthquakes, Volcanoes, & Plate Tectonics
The in-depth activities on this site range from virtual games, to interactive maps of earthquakes and volcanoes, and to quizzes you can take on the information presented.
http://sciencespot.net/Pages/kdzethsci2.html

BBC Online—Walking with Dinosaurs
A fantastic web site that includes games, quizzes, fact files, and much more. When it comes to dinosaurs, this web site is one of the best and most complete sites.
available.http://www.bbc.co.uk/dinosaurs/

USGS—The Dynamic Earth: The Story of Plate Tectonics
A very in-depth discussion of the theory of plate tectonics. Includes information from the historical perspective up to the effect on people.
http://pubs.usgs.gov/publications/text/dynamic.html

The Earth's Layers
This site contains a general overview of the layers of the Earth. It continues to go "deeper" for more specific information about each layer.
http://volcano.und.nodak.edu/vwdocs/vwlessons/lessons/Earths_layers/Earths_layers1.html

Activities and Worksheets

On the Web

You've Got the Whole World In Your Hands
Create your own model of the Earth's layers with a foam ball.

Dino Connections
Become a paleontologist and learn the difficulty of assembling fossils.

Just How DO These Plates Move?
Discover convection currents and how they explain the movement of Earth's plates.

Layering of the Earth

Purpose

To identify the layers of the Earth

Materials

Earth diagram cards (p. 19)
scissors
metric ruler
markers

Procedure

1. On the Earth diagram card sheet, cut along the solid lines, creating four separate cards.
2. Use a metric ruler and measure 1.5 cm from the bottom of each card and mark.
3. Draw a line horizontally across the bottom of the card at the mark.
4. At the bottom of one of the cards, write the word "crust."
5. On the same card, use a red marker to outline the crust of the Earth.
6. Repeat with each of the other cards, using "inner core," "outer core," and "mantle," coloring in the appropriate layer of the Earth to match.
7. Using markers, make different colored dots for each card in the top left and bottom right corners.
8. Use the scissors to cut the card along the line that was drawn at the bottom of each card to create a label card.
9. Practice matching each picture to the correct label card. To check to see if you matched them correctly, turn the cards over and check to see if the dots match.
10. Practice with a partner until you are able to identify the layers of the Earth without the labels.

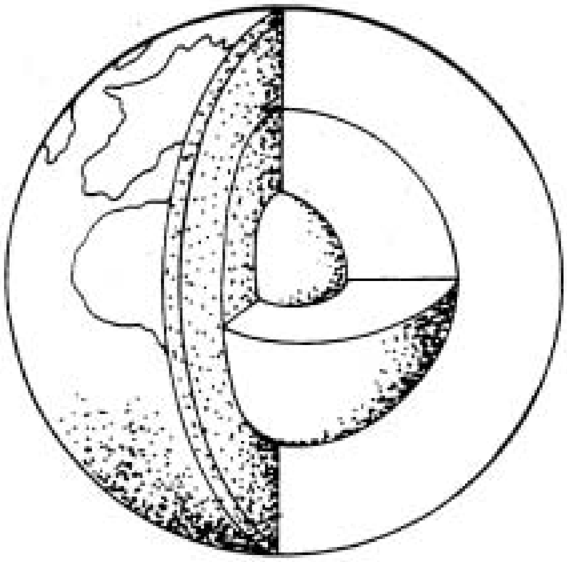
Conclusion:

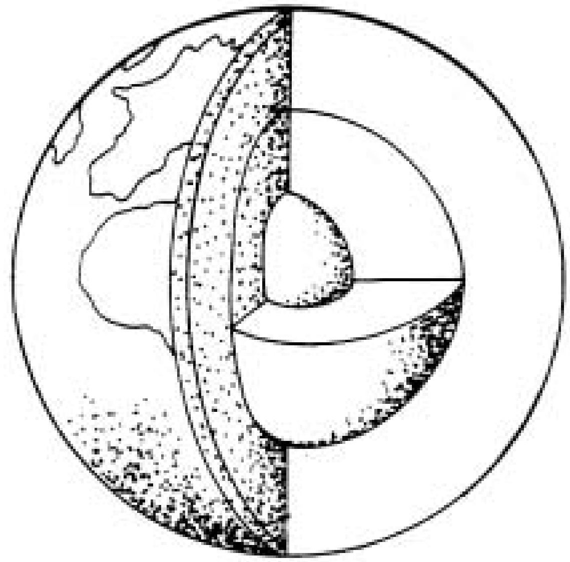
1. Which layer of the Earth do we live on?
2. What is the inner most layer of the Earth?

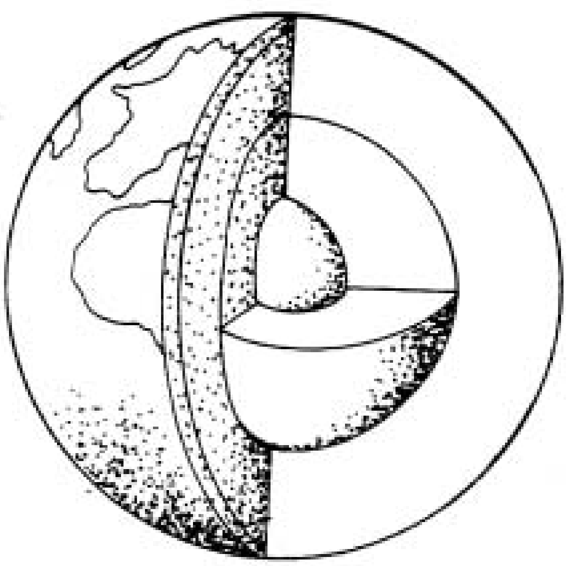
Extension:

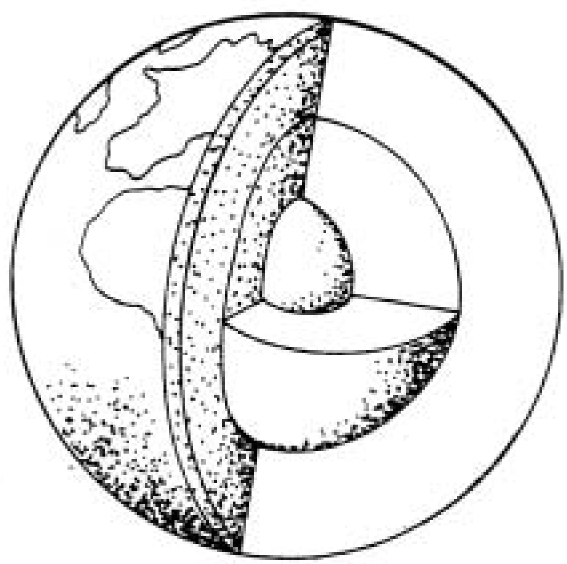
1. Research the layers of the Earth and write a brief description of each layer. Be sure to include what it is made of, how thick it is, whether it is solid or liquid, and so on. Present your findings in a report to the class.
2. Use a hard-boiled egg or a Ding-Dong® cupcake cut in half (with a small piece of candy for the middle) to discuss the layers of the Earth.

Earth Diagram Cards









Density Determines the Layers

Purpose

To determine how the density of a substance can create layers

Materials

3 small cups (of any kind)
1 large transparent cup
food coloring
water
corn syrup
cooking oil

Procedure

1. Pour small, equal amounts of water, corn syrup, and cooking oil into the three cups.
2. Using a different color, add one drop of food coloring to each of the three cups and mix.
3. In your science journal, record what color was used for each substance.
4. One at a time, slowly pour the contents of each cup into the transparent cup.
5. Observe and record what happens to the three different liquids when they are poured into the same cup together.

Conclusion

1. Which substance was on the bottom? In the middle? On the top?
2. Why did the layering of the substance occur?
3. Using what you have learned about density, explain how the Earth's layers were formed.

Extension

Carefully pour the following ingredients into a tall glass so that each substance is poured down the inside of the glass: honey, syrup, dish detergent, colored water, cooking oil, and rubbing alcohol. Explain what happened and why some of the substances mixed together. What would happen if you put the substances in the glass in a different order? In your science journal, draw what you observed.

Did You Catch My Drift?

Purpose

To learn about the Continental Drift Theory and to create a map of Pangaea

Materials

continent pieces (p. 22)
construction paper
scissors
glue
colored pencils

Procedure

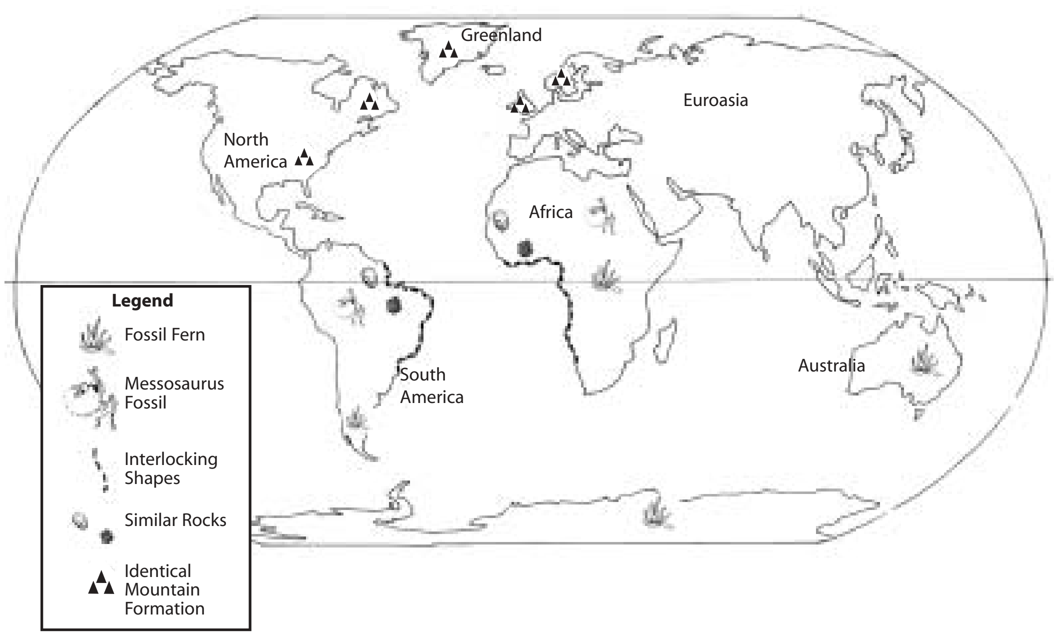
1. Color the legend using a different color for each fossil and rock clue.
2. Using the legend you created, color the fossil and rock clues on the continent pieces to match.
3. Lightly color each continent, being careful to not color over the clues.
4. Cut out the continent pieces.
5. Use the fossil and rock clues to arrange the continents into one large landmass.
6. Once you have determined the best fit, glue the pieces onto a piece of construction paper.
7. Cut out the legend and glue in the lower left corner.
8. Title your map "Pangaea."

Conclusion

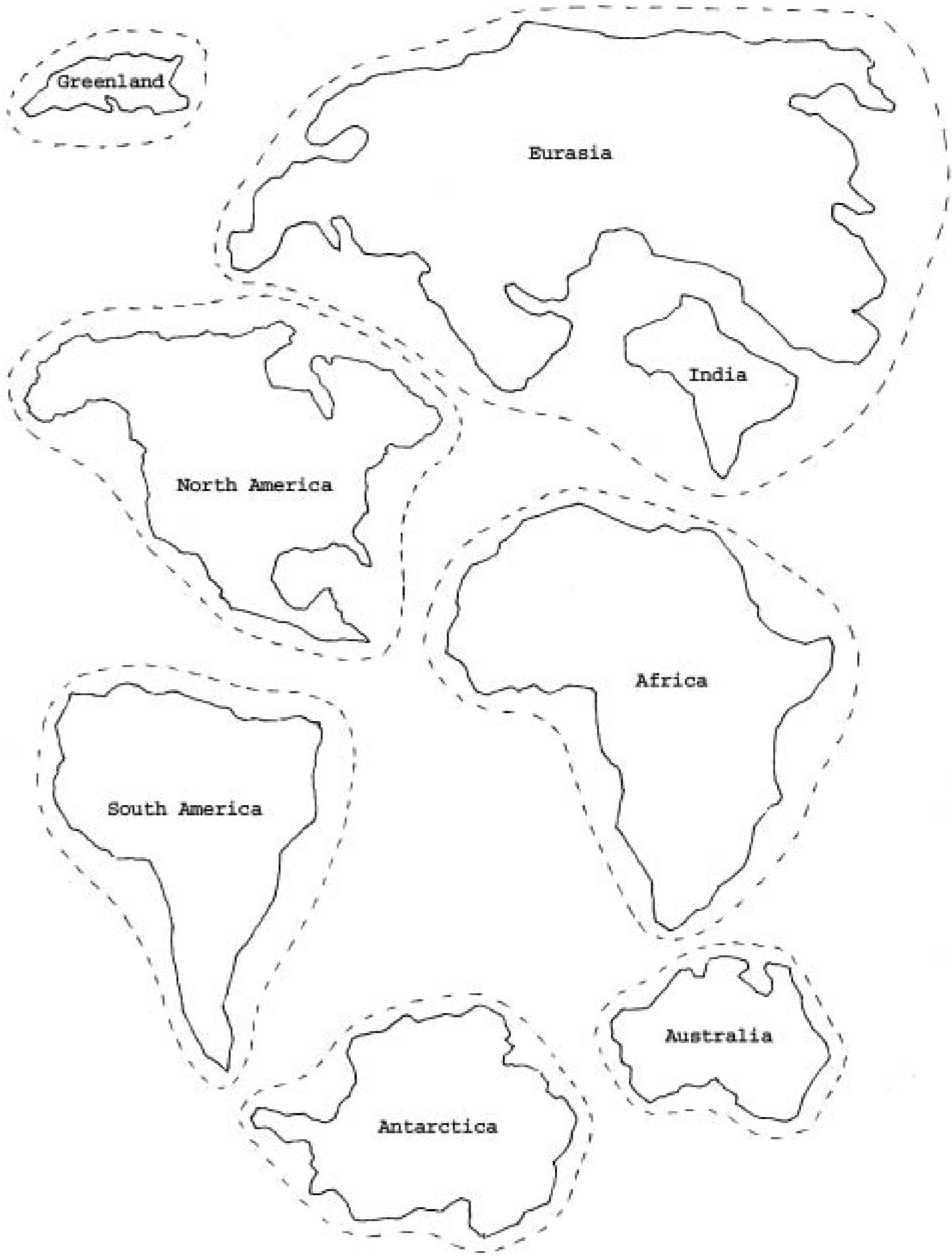
1. Which two continents have the best fit?
2. Why isn't the fit "perfect" if the continents were once part of Pangaea?

Extension

1. Suppose someone asked if the continents were really together at one time. What kind of information and evidence would you need to support the theory? Write a report explaining how the evidence supports the Continental Drift Theory.
2. After gluing the continents together, draw arrows indicating the direction that the continents have moved over time. Explain what might happen if the continents continue to drift in these directions.



Continent Pieces



Inventasaurus

Purpose: To learn the etymolgy of words

Materials

list of prefixes and suffixes
paper
pencil
colored pencils
construction paper

Background

Etymology is the study of the origin and historical development of a word or parts of words by determining its basic elements, discovering its earliest known use, recoding its changes in form and meaning, tracing its transmission from one language to another, and identifying its roots or origins in other languages. For example, dinosaur: dino means terrible and saur means lizard. A dinosaur is a terrible lizard.

Procedure

1. Look over the prefixes and suffixes and choose one or one of each to create a new name for a dinosaur. Be creative, think of your favorite movie star or singer and immortalize him or her as a new dinosaur. For example, Jacksonasaur.
2. Write a story about your new dinosaur, being sure to include when it lived, its size, what it ate, how it became extinct, who its natural enemies were, and any other important information.
3. Draw a picture of your dinosaur on the construction paper and present your newly discovered dino to the class.

Prefixes

archaeo, ancient
allo, other
bi, two
coele, hollow
compso, elegant
cory, helmet
crypto, hidden
dino, terrible
diplo, double
glyco, sweet
gorgo, terrible
herb, plant
hetero, different
hexa, six
megalo, great
mono, single
novo, new
osteo, bony
phyto, plant
proto, first
pseudo, fake
quadro, four
salto, leaping
stego, plated
tri, three
trach, duck
tyrannos, terrible

Suffixes

bracchis, arms
canis, dog
captor, hunter
cera, horned
docus, beam
dont, toothed
gnathus, jaw
ichthy, fish
nychus, claw
oculis, eye
ornis, bird
ossa, bones
ped, foot
pteryx, wing
raptor, stealer
rhynchus, nose
saur, lizard
suchus, crocodile
thorium, beast

Plates On the Move

Problem

To understand sea-floor spreading and the theory of plate tectonics

Background

Until the early 1950s, little was known about the ocean floor. The technology needed to explore the deep oceans had not yet been invented. Scientists began using echo-sounding devices to map the ocean floor, and they discovered a complex system of mountains and valleys, just like the continents above the water. They also found a system of ridges and valleys extending through the center of the Atlantic and other oceans around the world. These mid-ocean ridges form an underwater mountain range that extends through the center of much of the Earth's oceans. In the early 1960s, a scientist named Harry Hess suggested an explanation for these mid-ocean ridges. His now accepted theory is known as seafloor spreading. Hess suggested that molten material in the mantle rises to the surface at a mid-ocean ridge, and it then turns and flows sideways, carrying the seafloor away from the ridge in both directions. With the discovery of seafloor spreading, scientists began to understand what was happening to Earth's crust and upper mantle. The idea of sea-floor spreading showed that the continents were not just moving as Wegener suggested, but that there are sections of the seafloor and continents that move around in relation to one another. In 1968 scientists had developed a new theory that combined the main ideas of continental drift and seafloor spreading. The theory became known as the theory of plate tectonics, and it stated that the Earth's crust and upper mantle are broken into sections called plates. These plates move around on the mantle, and the continents can be thought of as "rafts" that float on the mantle.

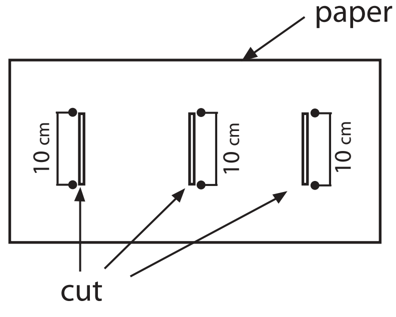
Materials

2 sheets of white paper
scissors
colored pencils
metric ruler

Procedure

1. Use the ruler to measure and draw three 10-cm lines on one of the sheets of paper. See diagram 1.
2. Draw mountain peaks between the edges of the paper and the outer lines.
3. Use scissors to make a slit along each of the lines drawn.
4. On the second sheet of paper, draw lines approximately 1 cm apart across the width of the paper.
5. Fold the paper in half lengthwise. Cut along the fold.

Diagram 1



Plates On the Move (continued)

Diagram 2

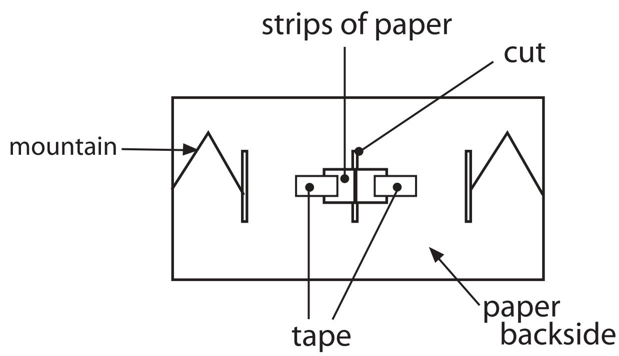
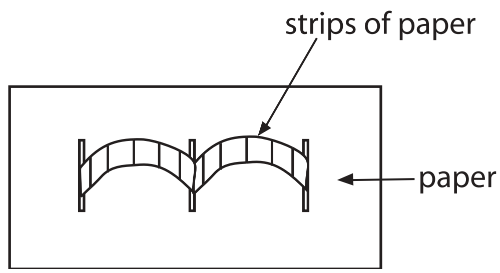


Diagram 3



6. Put the two strips face to face, matching the stripes in the middle.
7. Put them through the middle slit from the back to the front.
8. On the back, tape the strips to secure them in place. See diagram 2.
9. Pull both strips about 6 cm out of the center slit and insert each strip into the outer slit closest to it. See diagram 3.
10. Continue to pull the strips through the slit and observe. Record your observations.

Conclusion

1. What does the middle slit or opening of the model represent?
2. How is actual seafloor spreading similar to your model?
3. Where are the youngest rocks found on the ocean floor? The oldest rocks?
4. How does seafloor spreading support the theory of plate tectonics?

Extension

Research and perform experiments on convection to understand the mechanism that drives seafloor spreading. A convection activity can be found on the NASA SCI Files™ web site <http://scifiles.larc.nasa.gov> in *The Case of the Phenomenal Weather* guide on page 22.

Answer Key

Layering of the Earth

1. We live on the layer of the Earth called the crust.
2. The inner-most layer of the Earth is the inner core.

Density Determines the Layers

1. The corn syrup was on the bottom, the oil was in the middle, and the water was on the top.
2. The layering occurred because the substances were different densities. The corn syrup was the most dense with water being the least dense. If a substance is denser than something else, the substance will tend to sink to the bottom. This tendency is seen in this experiment. Since the volume of each of the three liquids was equal, and density is equal to the mass divided by the volume, the densest substance is also the heaviest substance. And, of course, heavier objects do sink to the bottom.
3. The layers of the Earth were formed as the denser materials sank to the inner portion of the Earth with the less dense materials, such as our crust, remaining on top.
4. **Extension**: Some of the liquids such as detergent and water, will mix together because the chemicals will dissolve each other. Some of the liquids, such as water and oil, will stay separate because they do not mix.

Did You Catch My Drift?

1. South America and Africa have the best fit.
2. When looking at the continents from a map perspective, much of the continent is not seen. We only map the part of the land that is above the surface of the water. However, much of each continent is below the surface of the water as they extend below sea level as continental shelves. Because of this, the continents do not fit perfectly.

Plates On the Move

1. The middle slit represents a mid-ocean ridge where the molten materials from the mantle rise to the surface of the Earth. This ridge is also known as a divergent plate boundary.
2. The model resembles actual seafloor spreading in that it shows how the molten material rises to the surface and then spreads out in both directions. The striped lines can represent the rocks being formed at the same time on either side of a ridge or they can represent the magnetic field of the crust and how it has reversed over time. Scientists have found that rocks on the ocean floor show many magnetic reversals and that the reversals align on both sides of a ridge.
3. The youngest rocks are located at the mid-ocean ridge, and they become increasingly older the farther they are from the ridge on both sides. Remember pulling the strips out of the slit? The ones that came out first (oldest) are now on the outer edge. Scientists also found that no rocks are older than 200 million years, even though continental rocks are more than three billion years old.
4. By examining the clues of rocks and fossils and proving that the seafloor spreads, scientists were able to support the theory of plate tectonics.

On the Web

You've Got the Whole World in Your Hands

1. The layers of the Earth are the inner core, outer core, mantle, and crust.
2. We live on the Earth's crust.

Dino Connections

1. Answers will vary but might include that it was difficult to put the pieces together because some of the pieces are crushed or that there were three "fossils" mixed together.
2. When paleontologists work in the field to piece together fossilized bones, they are not always sure if all of the bones are present. Some may have been destroyed by other dinosaurs at the time of the animal's death or simply not fossilized. Earth's processes such as floods, earthquakes, and such may have also disturbed the bones.
3. Apatosaurus was named a Brontosaurus until scientists discovered that bones in his head were not correctly put together.

How DO Those Plates Move?

1. The paper circles move around on the surface of the water. As the ice cools the surrounding water, it sinks to the bottom of the dish. As the cooler, denser water sinks, it forces the warmer less dense water to rise and replace the cooler water. As the warmer water moves and cools, it sinks and the cycle is started once again. This motion of sinking and rising causes the paper circles to move.
2. Some of the red food color will rise to the top and float towards the other end of the dish.
3. Some of the blue food color will sink and move along the bottom of the dish towards the other end of the dish.
4. Answers will vary but should include that the mantle material close to the Earth's core is very hot. Mantle material farther from the core is cooler and denser. The cooler material sinks towards the Earth's core and the hot material is pushed up to replace the cooler material. As the cooler material starts to sink near the core, it gets heated and starts to rise once again. Thus, the cycle continues over and over. This circular motion carries the plates along with it, which in turn causes the continents to move.